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## THRUST 2 ORDNANCE

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### USER NEEDS

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The focus of this Thrust is to provide affordable, high probability of kill, conventional weapons to the Air Force inventory. The user needs presented below are extracted from Operational Requirements Documents, munitions TPIPT study efforts, the ACC Mission Area Plans for Aerospace Control, Strategic Attack/Interdiction, Close Air Support/Interdiction, Theater Missile Defense, Electronic Combat, and the Air Force Special Operations Command (AFSOC) Weapons System's Roadmap, 2nd Edition.

#### AIR-TO-SURFACE

##### *Smart Hard Target Munition*

- Increased aircraft loadouts through reduced warhead size and compressed carriage
- Smart fuzing to optimize warhead burst point
- Increased mission kill capability and payload flexibility
- Neutralize biological and chemical targets
- Unitary heavy metal penetrating warheads
- Antijam GPS capability

##### *Smart Soft Target Munition*

- Insensitive explosives to reduce safety hazard
- Improved height-of-burst determination
- Jam resistant proximity sensor
- Enhanced kill mechanisms for increasing effectiveness of smaller weapons

##### *Small Smart Bomb*

- Increased aircraft loadouts through reduced warhead size and compressed carriage
- Smart fuzing to optimize warhead burst point
- Increased mission kill capability and payload
- Force multiplier munitions flexibility

##### *Antimateriel Munition*

- Multimode warhead effective against a broad spectrum of materiel targets
- Insensitive explosive for submunitions
- Reduced cost per kill and increased kills per aircraft sortie

#### AIR-TO-AIR

##### *Dual Range Missile*

- Improved warhead burst point control
- Enhanced lethality warheads
- Fuzing for low observable threats
- Guidance integrated fuzing
- Increased maneuverability, performance, and aircraft loadouts

See Figure 6 for major Thrust efforts.

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### GOALS

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#### AIR-TO-SURFACE



Figure 7. Penetration Test on Hardened Aircraft Shelter

**For Smart Hard Target Munition options, we develop ordnance capable of penetrating complex hard targets such as heavily hardened command and control bunkers, aircraft shelters (Figure 7), runways, and concrete buildings.** We also develop smart fuzing technology with layer counting, depth of burial, void sensing, and programmable time delay capabilities. To improve weapon accuracy and performance, we use low cost inertial guidance and optimized impact conditions through trajectory shaping and the use of reaction control systems so that the weapon and weapon velocity are orthogonal to the target plane at impact for better penetration.

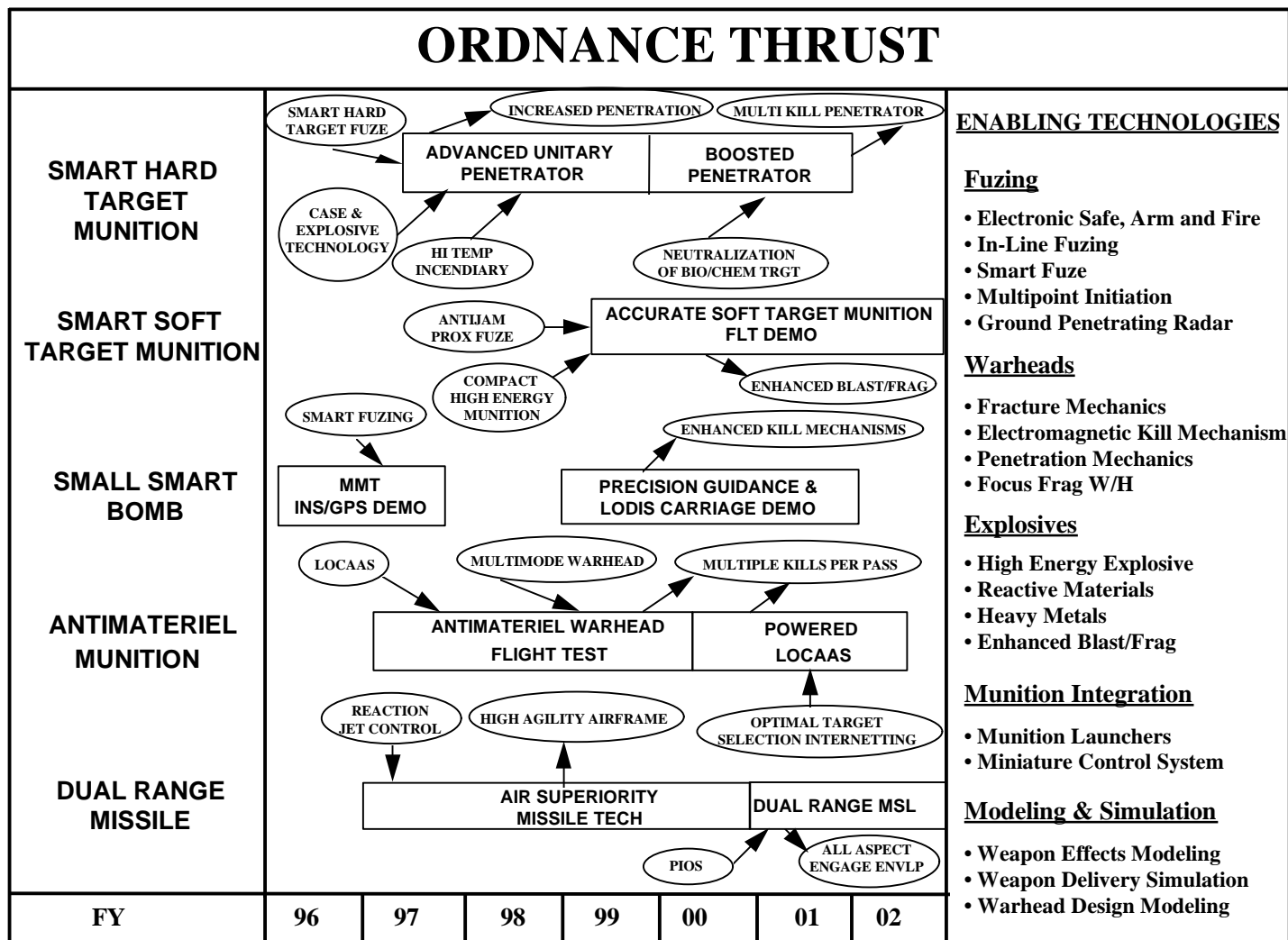


Figure 6. Thrust No. 2 Ordnance

Warhead case and hard target fuzing technologies are emphasized to reduce cost, improve productivity, and increase reliability of penetrator munitions.

For a given impact velocity, the penetration capability decreases with the decreasing size and weight of the penetrator. However, the number of weapons that a platform can carry increases with the decrease in penetrator weight. Extensive trade studies based upon cost and effectiveness indicate that a two-pronged approach is best: a high payoff, deep penetration capability and an increased force multiplier capability (carriage of more weapons).

- Develop velocity augmented warhead technology which can accelerate warheads for deep penetration, but at sizes and weights which can be carried on a variety of attack aircraft. The ordnance package would be an option for a replacement for the gravity drop BLU-109 warhead presently planned for JDAM.

- Develop options for heavy metal penetrating warheads. The payoff would be improved penetration over the present steel case designs (more weight per cross section) for both gravity and velocity augmented concepts.

Operational effectiveness is degraded when using fixed time delay fuzing because accurate intelligence data on the design and construction of all hard targets is lacking. A layer counting fuze with a void sensing capability only requires general construction data about a target to be optimally effective.

- Develop a smart fuze with void sensing and layer counting capability to provide accurate warhead burst point control for complex hard targets. The fuze will count floor layers and detonate the warhead in a predetermined void (room).

- Develop ground penetrating radar fuzes for interrogating buried targets prior to weapon impact. This interrogation will allow the selection of an optimum penetration depth in real-time. This will in turn increase the weapons effectiveness; therefore lowering the number of sorties and minimizing the overall cost to the warfighter.

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Current and developmental air-to-surface weapons are typically right circular cylinders with large aero-

surfaces and control fins that steer the weapon to the target. These weapons require large areas/volumes for aircraft carriage and have large incarriage drag and signature. This type of control system provides limited maneuverability for optimum penetrator impact conditions. Reaction jet control technology coupled with an on-board inertial measurement unit and improved guidance laws reduce attack angles, thus optimizing the impact angle which significantly improves the weapon performance and effectiveness.

- Develop weapons which can be carried conformally or internally with minimum stowage volume. Implement control systems with minimum span aerosurfaces or reaction jet controls which provide additional reductions to weapon size. Resulting systems will be compatible with external carriage on current aircraft and internal carriage on future advanced fighter aircraft.

- Develop detailed six-degree-of-freedom simulations to predict/optimize flyout and terminal performance of munitions with advanced aerodynamic control technology and conformal shapes.

**Penetrator design requires a thick walled warhead case for increasing penetration and ensuring warhead survivability during the penetration event. This thick wall requirement results in low volumes for explosive fills; which, in turn, drives a requirement for higher energy density explosives and new target defeat mechanisms.** These advanced target defeat mechanisms can be used individually or combined to provide the effectiveness needed. Target defeat technologies are being developed to defeat large hardened targets such as command, control, and communication facilities and biological and chemical weapon facilities.

- Develop revolutionary explosive fills for penetrator warheads. High density fills with enhanced energy density will provide increased warhead penetration while providing enhanced lethality. This technology would increase the effectiveness of the smaller warhead options for JDAM product improvement.

- Develop electromagnetic energy weapon payloads which provide wide area mission kills against targets that rely upon computers, communication, and power

systems. Methods for effectively coupling energy from the weapon into the target will be investigated.

- Develop warhead payloads for defeating/neutralizing weapons of mass destruction. Investigation of explosives, catalysts, and high temperature incendiaries as effective kill mechanisms will be accomplished.
- Develop innovative kill mechanisms that will neutralize or deny access to biological and chemical agents in hardened storage or production facilities.
- Develop the Modular Effectiveness/Vulnerability Assessment (MEVA) modeling and simulation methodology to perform effectiveness analyses of conceptual munitions employed against hardened targets. MEVA payoffs include optimized component technologies, robust system designs, and reduced experimentation requirements.

Battle damage assessment for hard buried targets is very difficult. Visual inspection of the target area usually provides little, if any, information on the weapon's effectiveness against the target. **Providing real-time data to airborne assets would maximize sortie effectiveness.**

- Develop miniature weapon borne sensor packages for penetrating warheads that will enable the transmission of battle damage information from inside the buried target.

Smart Soft Target Munitions (general purpose bombs) use proximity sensors to increase blast and fragmentation effects on soft targets. These sensors are expensive, bulky, and susceptible to electronic countermeasures (ECM) and jamming. Because they currently perform only the sensing function, the present bombs are required to carry a supporting initiation fuze which adds to the associated build-up costs of the bomb.

- Develop and demonstrate solid-state electronics and an ECM hardened proximity sensor for product improvement for the Joint Programmable Fuze.
- Develop monolithic microwave integrated circuits (MMIC) and wideband radar technology while

lowering the cost and improving the reliability and supportability of proximity sensors.

- Incorporate all sensing and fuzing functions into a single soft target smart fuze.
- Develop digital signal processing to reduce sensor susceptibility to ECM jamming.

**Aircraft costs are directly related to aircraft weight, thus a continuing emphasis is reduction in size and weight of the total weapon system (aircraft, suspension and release equipment, and armament). Kill mechanisms for delivering more energy on the target or more effectively coupling energy into the target are being explored.** These technologies provide the opportunity to reduce the weapon size and weight while maintaining the effectiveness currently available in larger munitions. Smaller, highly effective weapons result in reduced aircraft stowage volumes/areas and thus reduced aircraft size, weight, and costs.

- Develop and demonstrate innovative warhead, initiation, and explosive technologies for enhancing the effectiveness of 1000-lb class general purpose bombs so that their effectiveness is equivalent to the MK-84 2000-lb general purpose bomb.

- Develop carriage and release technology to reduce supportability costs through advanced energy sources which replace pyrotechnic devices. This technology will allow increases in flexibility of weapon loadouts, accommodating a wide range of weapon types.

- Develop innovative kill mechanisms which couple explosive and electrical energies to enhance the destructive power delivered to the target. Investigate capabilities obtainable from simultaneously applying multiple kill phenomenology to targets.

- Develop analysis and simulation capability for predicting the effects of novel kill mechanisms employed against a range of fixed soft targets including military headquarters buildings and high-value industrial sites.

- Perform comprehensive effectiveness trade studies for a wide range of aircraft and targets to determine goals for munition size/loadout and kill performance.

The most widely used form of airborne and ground test data is photography obtained with high speed film cameras. Computer processed metric analysis of high speed film is a standard data gathering technique. Film test data suffer many shortcomings, not the least of which is that film processing takes days and data quality is not known until that time. Weapon test programs are impeded by film processing delays. Film processing chemicals are also an environmental hazard and present severe operational restrictions.

- Develop high resolution, high speed electronic imaging systems which can replace high speed film camera systems and provide test data in real time. Both airborne and ground applications are being pursued. Payoff will be "film quality" image data that will be available to test and project personnel during the actual conduct of the test. Data quality will be immediately known and scarce test resources can be optimized in real time. Operational uses such as reconnaissance and strike battle damage assessment are immediate spin-offs of this technology. Elimination of wet-chemical film processing completely solves the associated environmental problems and improves field deployability.
- Develop ultra-high speed, 1 million frames per second electronic imaging technology for measuring short duration transient phenomenon. The combination of pulsed laser illumination with this technology will offer completely new capabilities for studying warhead initiation and detonation physics.

**Future fighters, such as the Advanced Tactical Fighter and the Joint Strike Fighter, demand that the weapon payload size and weight be reduced.** The Small Smart Bomb (SSB) family of weapons will provide weapons which combine precision guidance with enhanced burst point control and enhanced energy explosive fills to defeat targets currently requiring much larger warheads. These technologies will reduce weapon cost while increasing aircraft loadouts and reducing sortie requirements.

- Develop inertial aided small bomb technologies for hard targets which would provide multiple carriage per aircraft station and defeat multiple targets on a single sortie. Technologies required are low cost inertial guidance and second generation Smart Fuzing

(autonomous decision making rather than preprogrammed).

- Develop smart fuzing technology for 250-lb class weapons. Effective fuzing against thin layered structures as well as hardened targets consisting of up to 6 feet of reinforced concrete is required.
- Develop miniature munitions which integrate advanced ordnance technologies developed under the Smart Hard Target Munition and Smart Soft Target Munition areas to provide a family of weapons with increased loadouts and sortie effectiveness. For the first generation of small munitions, develop a 250-lb warhead capable of penetrating 6 feet of concrete and defeating 85 percent of the BLU-109 target set. This first demonstration will utilize a GPS/INS guidance system. Demonstrate an integrated terminal seeker version of the miniature munition with precision guidance and technologies for enhancing warhead effectiveness against soft targets.
- Utilize MEVA simulation methodology to conduct a multivariate trade study of the Small Smart Bomb point design, optimizing guidance, penetration, fuzing, and blast/fragment lethality requirements.
- Evaluate SSB concept terminal flyout performance and effectiveness via detailed simulation and analysis to include investigation of such issues as seeker and GPS trade-offs and guidance law operation.
- Develop simulation models to represent the SSB and associated technologies.

**The effectiveness of advanced munitions is, in large measure, dependent upon warhead design, where the development trend is toward much smaller explosive fills, coupled with multimode, aimable operation. Improved warhead effects instrumentation must be available to support development of new warhead designs.** Current warhead effects instrumentation is too costly and does not have sufficient bandwidth to support intra-warhead data acquisition. Warhead fragment pattern analysis is difficult, with the primary data source, high speed X-ray, providing only orthogonal views of the event. Present explosive temperature measurement techniques are inaccurate.

- Develop low cost, wideband blast instrumentation to support weapons research activities. This includes the development of both sensors and their support equipment.
- Develop real-time holographic warhead fragment pattern characterization that will ultimately yield increased warhead lethality through improved understanding of the warhead fragmentation process.
- Develop spectrographic methods to accurately measure explosives reaction temperatures. Accurate temperature data is required to validate and improve warhead computer models which are used to develop new munition concepts.

Real-time telemetry from developmental weapons is essential for ascertaining whether the system and subsystems function properly under realistic flight conditions. Current telemetry systems are too large to allow instrumentation of smaller munitions and submunitions. Even where size is not prohibitive, high telemetry system costs limits instrumented tests to only a few items.

- Develop weapon effectiveness telemetry by combining subminiature telemetry and smart fuze technologies. Payoff will be indication of proper weapon positioning and fuze function.

**Strategic attack, interdiction, and close air support will continue to be primary missions for advanced tactical aircraft. Targets include enemy air defenses, tactical ballistic missile sites, and the whole range of ground mobile targets such as those included in a motorized rifle battalion.** To meet the user's need for defeating a broad spectrum of antimateriel targets, the multimode warhead with enhanced lethality will be developed and integrated with the Antimateriel Munition. The large number of targets and limited aircraft carriage capability require a cluster munition approach to defeat dispersed ground targets.

Until recently, different warheads had to be fielded to get the optimum lethality for each different class of target. Armament Directorate in-house development has demonstrated the feasibility of a single warhead being initiated in any one of the three modes (long penetrating rod, explosively formed aerostable penetrator, or fragmentation). This technology

breakthrough enables one submunition to be lethal against the wide spectrum of materiel targets. Concurrently with the multimode warhead, the Advanced Guidance Thrust has developed an affordable diode pumped laser radar seeker which can classify, in real time, targets such as tanks, trucks, relocatable missile launchers, or radar sites. This seeker and a maneuvering submunition airframe have matured in the Low Cost Autonomous Attack Submunition (LOCAAS) program. The Antimateriel Munition of the future is envisioned as a second generation smart submunition that will combine autonomous target classification with significantly increased area coverage with a selectable multimode warhead. Detailed cost projections verified by independent government cost analysis indicate these submunitions could be built in large quantities for under \$20K each. Joint service use of these effective munitions against ground, mobile targets requires them to be carried safely on Navy ships with Navy insensitive munition requirements.

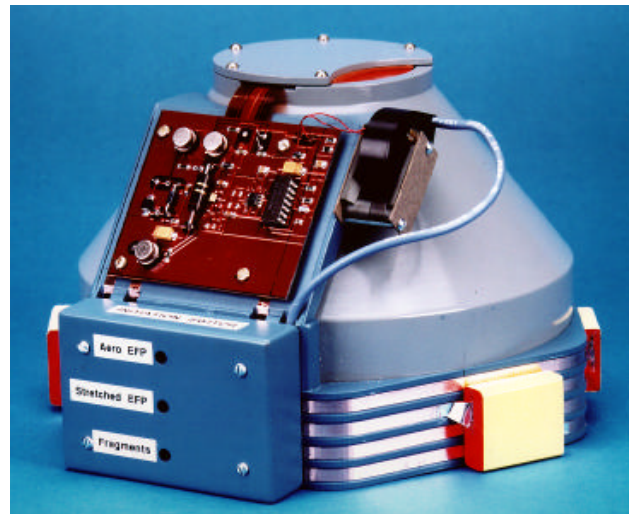


Figure 8. Antimateriel Submunition Warhead (8.5 inch diameter, 6 inches high)

- Continue advancement of multimode warhead technology which can be selectively fired as a penetrating jet, aerostable slug, or multiple fragments. This will provide technology options for next generation antimateriel submunitions. The Antimateriel Submunition Warhead is shown in Figure 8.

**Current antimateriel submunitions are limited in their area coverage and search patterns. They also have limited lethality against the broad spectrum of**

**antimateriel targets which includes armored vehicles, trucks, and missile sites.**

- Develop high density carriage and dispensing technology to allow large increase in aircraft loadout of antimateriel submunitions.

- Continue development of low cost antimateriel submunitions which provide significantly lower cost per kills than existing submunitions.

- Develop technologies for incorporating multiple kill methods into a single antimateriel submunition thus providing improved cost per kill. Potential mechanisms include conventional, explosively projected fragments and projectiles, conductivity of high energy currents, and transmission of high powered electromagnetic pulses.

- Analytically assess the effectiveness of current multimode warhead design against varied target sets. The results will highlight design requirements for next generation antimateriel submunitions employing multiple kill mechanisms.

- Refine LOCAAS flyout simulation for improved performance prediction to optimize warhead standoff parameters and munition software which determines warhead burst position.

In order to maximize the number of kills per sortie, multiple kills of the same target must be avoided. Multiple autonomous munitions must have a method of coordinating an attack.

- Develop telemetry technology which will enable effective networking of multiple submunitions to maximize the number of kills per sortie.

**AIR-TO-AIR**

Enhancement of air-to-air ordnance package performance requires that the target detection device and warhead burst point calculations use all information available to the missile. Effective coupling of the warhead energy onto the target requires improvements in directing the kill mechanism so that as much of the kill mechanism as possible interacts with the target. Data from the missile seeker can be used to project the encounter geometry and velocity. Further enhancement of the burst point control algorithms

requires that the volume viewed by the target detection device be expanded to cover as much of missile forward hemisphere as possible. Reductions in target signatures require that the fuze be capable of detecting low observable targets.

- Develop guidance integrated fuzing systems which accurately predict the relative target encounter conditions using all available data from the seeker and guidance systems.

- Develop an imaging seeker/fuze sensor which covers the forward hemisphere and provides missile/target encounter geometry refinement and a preferred target aimpoint for enhancing warhead burst point calculations and improving warhead effectiveness.

- Develop mass focusing warheads which direct the fragment and blast patterns so that the majority of the warhead energy is coupled into the target.

- Develop fuze sensors which have greater detection ranges against low observable targets in weather.

Improvements in enemy aircraft technology and the proliferation of advanced aircraft have resulted in nations possessing fighter aircraft nearly equal to our own. The weapons suite for these aircraft is in some areas (e.g., aerodynamics) superior to our current systems. Technologies such as reaction jets will eliminate the need for missile fins, providing compressed missile carriage which will double missile loadouts for a given carriage volume. This technology should be developed with the goal of supporting future product improvements to the AIM-9 Sidewinder and AIM-120 AMRAAM systems. Additionally, the munition control system technologies of the thrust are also applicable to the air-to-surface weapon systems.

- Develop technologies for increasing missile maneuverability and high off-boresight launch capabilities. These technologies will provide increased first shot opportunities and minimize the time required for missile launch and destruction of the enemy aircraft.

- Develop advanced, low cost, supportable, munition control system technologies which provide decreased missile flight times, high off-boresight, and high angle-of-attack launch capabilities.

- Develop evaluation methods for dual range missile concept terminal flyout performance and effectiveness via simulation and analysis to include investigation of such concepts as guidance integrated fuzing, advanced fuze sensors, and advanced guidance and control technologies.

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## MAJOR ACCOMPLISHMENTS

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### AIR-TO-SURFACE

- Completed Nonnuclear Munition Safety Board qualification of Hard Target Smart Fuze with void sensing capability for hard target weapons. Accomplished GBU-27 and GBU-28 Hard Target Smart Fuze flight tests against hardened underground targets and procured 40 units for testing and deployment in contingency operations.
- Completed large scale aerosol tests of agent defeat kill mechanism for neutralizing biological weapons.
- Completed design and test of hard target smart fuze for the miniature munition technology demonstration.
- Demonstrated penetration of 4 feet of concrete with miniature munition technology demonstrator.
- Accomplished full scale testing of advanced high density penetrator explosive fills for penetrator warheads.
- Completed vulnerability and lethality test with small warhead package for miniature munition technology demonstration.
- Continued scale tests of agent defeat neutralization payloads against chemical weapon agents.
- Completed integration of warhead and fireset for multimode antimateriel warhead brassboard.
- Completed wind tunnel testing for Miniature Munition Technology demonstration.
- Completed lethality assessment of Small Smart Bomb point design against in-theater targets including

hardened aircraft bunkers and surface-to-air missile sites.

- Completed preliminary internal dispersion methodology for assessing defeat of weapons of mass destruction facilities.
- Accomplished full scale tunnel vulnerability experiments in conjunction with other DoD services and international allies.
- Developed methodology for assessment of conceptual munition effectiveness against extremely hardened tunnel facilities.
- Completed LOCAAS simulation development to reflect the current technology configuration; validated the simulation against actual flight tests.
- Completed development of a baseline MMT six-degree-of-freedom (6-DOF) simulation.
- Developed 512 X 512 pixel, 1000 frame per second charge coupled device (CCD) electronic imager. It will be transitioned to a joint Navy/Air Force Airborne Separation Video EMD program for use as the video sensor in the airborne video camera.

### AIR-TO-AIR

- Completed testing of jet reaction control device for air-to-air missiles.
- Completed development of a baseline Dual Range Air-to-Air Missile six-degree-of-freedom (6-DOF) simulation.
- Produced ballistic holograms up to 18 inches in diameter using in-house laboratory facility. Conducted successful initial experimentation to develop remote holographic camera for use in warhead arena testing.
- Transitioned Noncooperative Vector Scoring technology to ASC/VXA. Program office selected this technology for the Air Force Interim Vector Scorer EMD program. Over 400 units will be built and used for flight operations over the next 3 years.
- Developed spectro-radiometer instrument to

simultaneously measure spatial and spectral infrared target signatures. Transitioned technology to AFDTC and AEDC.

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## **CHANGES FROM LAST YEAR**

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Received funding for heavy walled penetrator design, development, and testing from the OSD Counter Proliferation Initiative program managed by the Defense Nuclear Agency. A portion of the Armament Directorate work in the agent defeat area is being funded by the OSD and feeds an FY98 technology demonstration for the defeat of biological and chemical targets.

Starting in FY97 the Instrumentation Technology Thrust (Thrust 3 in FY96 TAP) has been deleted. Instrumentation Technology research has been incorporated into the Ordnance Thrust.

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## **MILESTONES**

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### **AIR-TO-SURFACE**

- Complete flight test demonstration of a 2000-lb advanced unitary penetrator warhead which provides greater than twice current warhead penetration capability in FY97.
- Complete parametric assessment of 2000-lb advanced unitary penetrator against hardened target set to optimize kill effectiveness while maximizing penetration requirements in FY97.
- Flight test the Battle Damage Assessment Telemeter in FY97.
- Demonstrate explosive recycling technologies which provide low cost recycling of military weapon explosives with environmentally safe end products in FY97.
- Complete development of a lethality/vulnerability methodology for assessing the defeat of the ground-fixed soft target spectrum. Validate methodology through full scale testing in FY97.
- Deliver final version of 1000 and 12,000 frame per second High Speed Charge Coupled Device Imagers to

support Ultra-high Speed Multiframe Electronic Camera development in FY97.

- Demonstrate 250-lb force multiplier warhead compatibility with multiple weapon carriage on a single aircraft station in FY97.
- Complete simulation studies to investigate seeker and GPS trade-offs in FY97.
- Demonstrate initial Energetic Material Pyrometry instrument design through in-house experiments in FY97.
- Demonstrate lethality of the multimode warhead against ground mobile and relocatable targets in FY97.
- Demonstrate Submunition Video Sensor in Antimateriel Munition flight test vehicle in FY97.
- Flight test Multiple Munition Telemetry Demodulator and transition to AFDTC in FY97.
- Develop technology for a 2250-lb munition with velocity augmentation and physical compatibility with the F-16, F-15, F-117, F-18, and B-1 by FY97-FY01.
- Demonstrate 2250-lb and 1000-lb warhead technology compatibility with inertial and precision guidance and develop flight control algorithms to ensure small angle-of-attack at impact in FY98.
- Complete ground test of advanced weapon carriage and release equipment for application to JAST and other aircraft in FY98.
- Demonstrate brassboard ground penetrating radar system for hard target penetrator fuzing in FY99.
- Complete development and sled track demonstration of 1000-lb class tungsten alloy case penetrator warhead. Penetration goal is three times the penetration of current system in FY99.
- Integrate the full capability to model enhanced energetics into the MEVA methodology for high confidence assessments of the defeat of the hard targets spectrum in FY99.

- Demonstrate countermeasure resistance proximity fuze for general purpose bombs. Demonstrate improved altitude resolution and high resolution height of burst capability in FY99.
- Demonstrate, through full scale tests, technologies for enhancing lethality of 1000-lb class general purpose bomb. Synergistic integration of warhead design and explosive enhancements will provide performance equivalent to 2000-lb general purpose bomb in FY99.
- Analytically assess the enhanced lethality of the 1000-lb advanced general purpose munition employing optimized kill mechanisms. Parametrically assess performance versus 2000-lb munition across entire soft target spectrum in FY99.
- Perform component integration and live fire flight testing of an all-up antimateriel submunition effective against all mobile ground targets in FY99.
- Configure detailed simulation to represent flight test vehicle and reduce test risk through preflight analysis in FY00.
- Flight demonstrate Multi-Munition Transceiver Techniques in FY00.
- Demonstrate Multi-Frame Holocamera through Warhead Arena experiments in FY01.
- Flight demonstrate high density packaging and dispense technologies for carriage and release of antimateriel submunitions in FY01.
- Completed development of a baseline Dual Range Air-to-Air Missile six-degree-of-freedom (6-DOF) simulation capable of performing concept trade-off studies to include flyout and effectiveness evaluation.
- Complete testing of imaging target detection device and electronic safe, arm, and fire device in FY00.
- Complete flight testing of reaction jet control system for missile agility and performance improved for short and medium range in FY00.
- Complete flight testing of air superiority missile technology providing short and medium range capability in FY01.

## **AIR-TO-AIR**

- Complete simulation studies to investigate optimal concept formulation in FY97.
- Complete development of flight control software for highly maneuverable, missile incorporating, hybrid reaction jet/aerodynamic flight controls in FY98.